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BETELGEUSE: HOW ITS DIAMETER WAS MEASURED

By C. A. CHANT

The remarkable feat of measuring the diameter of the bright star Betelgeuse, recently accomplished at the Mt. Wilson Observatory, has attracted wide attention. At the recent meeting of the American Association for the Advancement of Science, in Chicago, Prof. Michelson briefly explained how it was done, and perhaps the following elementary account of it may be acceptable.

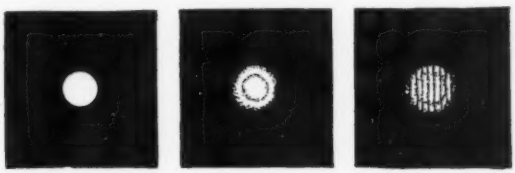


Fig. 1 Fig. 2 Fig. 3

Fig. 1, Image of a planet when viewed by a telescope.
Fig. 2, Image of a star, showing diffraction ring.
Fig. 3, Image of a star when a plate with two slits in it is placed over the objective.

Everyone who has used a telescope has remarked the difference between the images of a planet and a fixed star. The former shows a sharply-defined disc (Fig. 1) which appears larger, the higher the magnification; the latter appears only as a bright spot, without any clear boundary. Many people expect a great telescope to exhibit a star, such as Sirius or Arcturus, as a flaming fire, but the larger the instrument, provided it is of good quality, the smaller the image is, though, of course, the image in a large telescope is *brighter* than in a small one. On closely examining the image of a

star, however, there is seen a faint dark ring surrounding the bright spot (Fig. 2). There are in reality several rings, but usually only one can be detected. These rings are due to diffraction, or the bending of the waves of light from their straight paths, the dark rings being produced by the interference of the waves. This phenomenon is explained in any work on light or on the telescope.

In 1890 Michelson described some experiments on which the method followed in measuring Betelgeuse is based. He placed a disc with two slits in it in front of the objective of a telescope which was pointed at an artificial 'star' formed by a bright light behind a

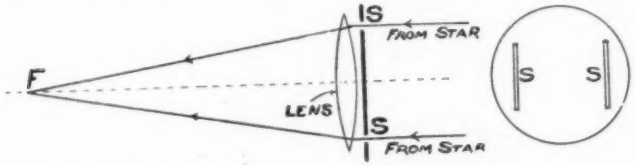


Fig. 4.—Showing a plate with two slits in it over the objective. Plan of plate with slits to the right. An image of the star is seen at *F*, with fringes across it.

small hole in a metal plate, placed a considerable distance away (Fig. 4). In this case there was seen at the focus F, the usual bright spot and ring, but in addition a series of dark bands, or fringes, across the image (Fig. 3). Then as the hole in the plate was enlarged, that is, as the 'star' was given an appreciable diameter, the fringes altered and at last vanished. Michelson showed by theoretical calculation, which was verified by experiment, that, when the fringes vanish a simple relation exists between the size of the hole, the distance between the slits and the wave-length of light. In Fig. 5 let MN be the hole in the plate, (i.e. the artificial 'star'), D be the distance between the slits S, S, α be the angle MCN, and λ the wave-length of light.

Then, $\alpha = 1.22\ \lambda/D$, (radians). If now the distance d of the star is known, its linear diameter can be determined. It is equal to αd.

The paper in which this result was given was published in the *Philosophical Magazine* in 1890, and in it Michelson remarks that the method might be used in measuring the diameters of small planets, satellites and possibly the fixed stars. Next year, by

invitation of the Lick Observatory, he tested his method on the satellites of Jupiter with decided success, his results being near to the mean of measurements made by astronomers with the micrometer. (See Michelson, *Light-Waves and their Uses*, p. 142.)

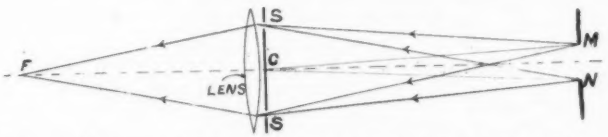


Fig. 5—Light from a source *M N* passes through slits in a plate and is then converged to *F*. When *M N* has a certain width the fringes at *F* vanish.

No further applications of the method were made until quite recently. Experiments on the interference of light-waves are notoriously hard to perform, requiring very accurate adjustments; and as the atmosphere is always in a disturbed condition it was feared that an attack on the fixed stars would be difficult and probably unsuccessful. However some preliminary experiments with the great 40-inch refractor of the Yerkes Observatory, made in August 1919, gave hopeful results; and at the request of Dr. Hale, director of the Mt. Wilson Observatory, Michelson went thither to try out the method with the 100-inch Hooker telescope. As this is a reflector some modification of the original arrangement was necessary. This is illustrated in Fig. 6.

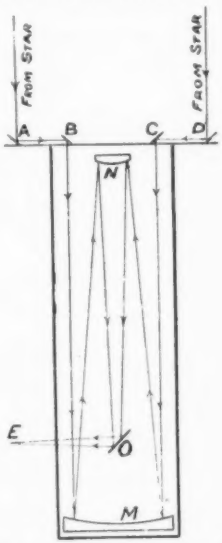


Fig. 6.—Diagram illustrating the optical arrangement used in the measurement of the star's diameter.

A steel beam was bolted to the upper end of the tube of the telescope and four plane mirrors, A, B, C, D, were mounted on it. The light from the star followed the path shown in the figure. One beam was reflected from A to B, then down to the great mirror M, then up to the convex mirror N, then back to the plane mirror O and

then out to E. Another beam entered by D and C, and, after following a similar path, also came out to E, where the two sets of waves could interfere and the fringes be observed. The mirrors A and D in this arrangement correspond to the slits S, S, in Figs. 4 and 5. The mirrors B and C were 4 feet apart and, to begin with, A and D were 6 feet apart. The telescope was directed at Betelgeuse and with much patience the fringes were obtained. Then A and D were separated. When about 8-feet apart the fringes showed sings of change and when 10-feet apart they vanished. That is, the distance D was 10 feet or say 3000 mm. The wavelength of the light was taken to be 0.000555 mm.

Hence $\alpha = 1.22 \times 0.000555/3000$ radians,

$= 0''.046.$

The parallax of Betelgeuse is approximately $0''.018$, or its distance 181 light-years; from which it follows that the diameter of the star is about 240,000,000 miles.

To test whether the apparatus was really in adjustment yet the telescope was turned towards Procyon and the fringes appeared. This showed that the vanishing of the fringes had not been due to the apparatus being out of adjustment, and that the angular diameter of this star was not as great as that of Betelgeuse.

The actual experimenting was done by Dr. Anderson and Mr. Pease of the Observatory staff and it was described as "tedious and difficult;" to them much credit is due for the successful outcome.

THE ASTRONOMER

When crooning breezes whispered
  Their lullabys of rest
The evening star was sinking
  To cloudlands of the west,

And tired folk lay breathing
  'Neath brooding wings of sleep
While through his lens of wonder
  The star-man scanned the deep.

There, spread the dome of knowledge
  Inverted to his sight,
The dark, mysterious concave,
  The all-revealing night,

Where tranquil planets floated,
  Each in its fitful track—
Those vagabonds of heaven
  That dot the zodiac;

And, more intensely burning
  In horde and fiery clan,
Far up the gleaming archway
  A starry pageant ran.

The bright celestial torches
  Glowed with a pomp sublime;
The star-man marked their motion
  And called its measure "time."

One truth in beauty blazing,
  Graved on the night he saw,
A truth the stars were singing—
  The sovereignty of law.

April, 1921. ALBERT DURRANT WATSON.

A NOMOGRAM FOR USE IN SUNLIGHT ENGINEERING

By W. H. Herbert

Sunlight Engineering may be defined as the art of orientating the streets, buildings and windows so that the requisite amount of sunshine may be obtained. In the past, this subject received very little attention in city planning, laying out subdivisions, etc. Generally the direction and width of streets, arrangement of lots and dimensions of blocks have all been fixed without considering the solar astronomical conditions.[1]

In order that the requisite amount of sunlight may be obtained it is necessary that the height of buildings, size and depth of windows and rooms, dimensions of courts, etc., should be determined in conjunction with solar astronomical conditions.

In northern latitudes during the winter season, the low sun and short day are great disadvantages. Under these conditions it is necessary to utilize to the best advantage the amount of sunlight available. To do this it is necessary to know the azimuth and altitude of the sun for any time of day during any day in the year for any latitude of station. When this information is available the length and direction of shadow can be easily determined. To determine the sunshine received through a window it is perhaps preferable to consider the window as being opaque and the wall as being transparent, when the surface illuminated becomes the surface in shadow, to be solved as above.

In any case, when the length and direction of shadow are known, the area in shadow may be plotted easily for different periods of the day. The shadow on any plane at any angle may be plotted by descriptive geometry.

The whole problem of sunlight engineering, therefore, may be considered as a problem in determining the azimuth and altitude of the sun with respect to time, date and latitude.

From the nature of the case it will be seen that approximate results are amply sufficient.

The altitude and azimuth of the sun can be found by solving the astronomical triangle by means of spherical trigonometry—a branch of mathematics practically unknown to many people. Also the solar astronomical triangle is capable of many configurations which greatly increase the labour involved and necessitate remembering many special rules for special cases. But solving the astronomical triangle may be said to constitute the most important work involved in sunlight engineering.

Previous Solutions

The best known means of performing this work is by the use of tables having the known quantities as arguments.

These azimuth tables are divided into two essentially different classes: altitude-azimuth and time-azimuth.

In the Azimuth Tables of Thomas Lynn, Commander in the late East India Company's service, which were published in 1829, the sun's altitude is the chief element involved for finding the azimuth; as is likewise the case in Captain Blackburn's valuable A and B tables,[2] which are useful, among other purposes for deter mining altitude-azimuths.

In order to shorten the tables and conserve space, the great majority of time-azimuth tables have been based on the two component right-angled triangles of the astronomical triangle. Towson's Great Circle Tables and Lunar Index[2] give the true bearing of a celestial body when the hour-angle or apparent time is known. Lord Kelvin's hour angle and azimuth tables,[3] and Fuss' altitude and az'muth tables[4] are founded upon Napier's analogies. In more recent times tables for the same purpose have been published by M. Hommey, 1863; and Mr. Davis of the "Nautical Almanac" office, 1897

As a recent example of time-azimuth tables using the two component right-angled triangles of the astronomical triangle, may be cited the "Altitude and Azimuth Tables" of Lt. Radler de Aquino.[5] Probably the best examples of time-azimuth tables are the "Sun's True bearing, or Azimuth Tables" by Staff Commander Burdwood, R.N.,[6] and H. O. Publications Nos. 71 and 120 issued by the U.S. Navy Department.[7]

In general these tables require the use of many special rules and do not give the altitude of the sun. They are, therefore, not of very easy application in problems of sunlight engineering.

Another means of solving the astronomical triangle is by the use of diagrams, abaci and nomograms.

Mr. G. W. Littlehales, Hydrographic Engineer, has published a large book of diagrams or abaci by means of which the altitude and azimuth may be determined graphically.[8] The work involved is very little, but so many intersecting systems of lines are confusing.

The abacus of MM. Favé et Rollet de l'Isle[9] is also published in book form but solves the triangle by means of the two right-angled component triangles. It, also, is open to the same defects as above noted, in that it is composed of four systems of superimposed lines and many special rules are also necessary.

The nomogram of Captain Lafay[10] consists of three diverging graduated straight lines. The nomogram of Dr. Pesci[10] consists of three graduated straight lines in the form of the letter N or Z. Both these nomograms use the two component right-angled triangles in obtaining a solution. However, very many rules must be followed for special cases, and the application of these nomograms is far from easy.

Dr. Deville's "Nomogram of the Altitude and Azimuth of the Pole Star" applies to a particular case of the solution of the astronomical triangle[11]. In this nomogram, however, no special rules are necessary. The construction is based on parallel scale co-ordinates.

Another variety of diagram is the abacus-nomogram, which combines aligned numbered points with systems of intersecting lines. Among these may be mentioned Collignon's nomogram[9] and the general nomogram for solving the spherical triangle.[9] They are not very simple of application, however, and in general also require the following of special rules.

For the purposes of sunlight engineering the above review showed that a suitable method was not available, and the whole question then took the form of devising a system that was suitable. The desiderata kept in mind were the application of the simplest possible construction with the fewest possible rules.

A parallel scale nomogram giving the altitude and azimuth simultaneously was designed for this purpose and its elements are presented herewith.

Preliminary Considerations

If the celestial sphere be considered as projected orthogonally upon the plane of the meridian, the parallels of latitude are shown as straight lines and the lines marking off the hour angles or meridians of longitude are shown as ellipses. If, now, another like projection, on transparent paper but with altitude and azimuth—written for declination and hour angle, respectively, be rotated on the same centre to the proper positions relatively to the first—determined by the latitude of the station—then a solution is readily obtained; with, however, the disadvantages of four intersecting systems of lines and rotation about the centre.

But if a system of concentric circles and radial lines be added to the first projection, the first projection becomes self-sufficient. The point of the celestial body is then located by means of the hour angle and declination. By shifting this point along the concentric circle on which it happens to fall through an angle equal to the colatitude of the station—as measured by the radial lines—the azimuth and altitude may be read off the hour angle and declination scales, respectively.

To put this projection into proper shape for a parallel scale nomogram, it is necessary that the systems of straight lines, circles and ellipses should be reduced simultaneously to systems of straight lines, which can be accomplished by plotting the projection with new values along the x and y axes; equal to the squares of the preceding or projected values. In other words: by changing the x and y scales of the projected values which are sine functions into the square of the sine functions, all the systems of lines on the projection are simultaneously reduced to the rectilinear form.

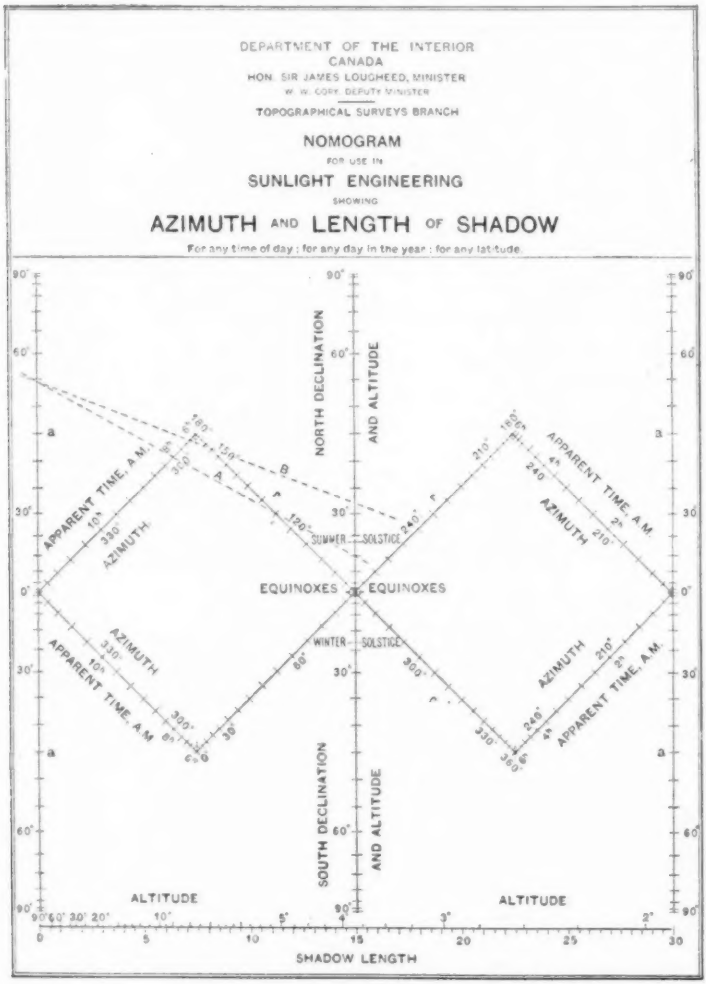
Design of Nomogram

The design of the parallel scale nomogram now proceeds as follows: On the diagram

Let a = sun's perpendicular distance from the meridian.
" r = radial distance from the south pole.
" t = sun's apparent time.
" d = sun's declination.

Then from the diagram the two following equations may be obtained:

1. $\cos^2 a - \sin^2 D = \sin^2 D / \tan^2 r$.
2. $\cos^2 a - \sin^2 D = \cos^2 D \sin^2 t$.



Referring to the accompanying figure, which shows the elements of the complete nomogram, it may be seen that the four quadrants are analogous, which makes it sufficient to describe the construction of only one quadrant, in this case the upper right-hand quadrant. The line "North Declination and Altitude" is the usual u scale, increasing from zero at the centre of the diagram upward in the positive sense; the line a, the upper half of the right-hand scale, is the usual v scale, increasing from zero at the upper end downward to the middle in the positive sense, the distance from the centre of the diagram to the upper end of the right hand scale is the usual distance, $2P$, and lies along the x axis; and y is plotted from this axis.

The first equation $\cos^2 a - \sin^2 D = \sin^2 D / \tan^2 r$ may be written $\sin^2 D\ (1+\tan^2 r) - \tan^2 r \cos^2 a = 0$.

Let $u = l \sin^2 D$ and $v = -l \cos^2 a$,
then $x = -P/(2 \tan^2 r + 1)$, $y = 0$.

The value of r therefore lies along the x axis, and is plotted as shown, from this equation.

The second equation $\cos^2 a - \sin^2 D = \cos^2 D \sin^2 t$ may be written $\cos^2 a - \sin^2 D\ (1 - \sin^2 t) - \sin^2 t = 0$.

Let $u = l \sin^2 D$ and $v = -l \cos^2 a$ as before, where l is some modulus.
then $x = P \sin^2 t/2 - \sin^2 t$, $y = -l \sin^2 t/2 - \sin^2 t$.

Eliminating t, there is obtained $x = -Py/l$, the equation of a straight line. This line may be drawn and the values of t plotted by using the equation for x or y as above.

It is only necessary now to remember that the hour angle and declination of one of the right-angled triangles correspond to the azimuth and altitude of the other right-angled triangle, respectively, to write in the values for the azimuth and altitude on the apparent time and declination scales.

It will be noted that if a straight-edge be pivoted at the centre of the diagram the apparent time or azimuth scale may be easily laid off by projecting the graduations on the "a" scale, and similarly, if a straight-edge be pivoted at the point 0 degrees on the a scale the r scale may be easily laid off by projecting the graduations on the north declination and altitude scale.

Method of Use

Align declination on Declination scale with apparent time on Apparent Time scale; and read off value of a on a scale and value of r on r scale.

Add co-latitude of station to value of r.

Align value of a on a scale with new value of r on r scale; and read off value of altitude on Altitude scale, and value of azimuth on Azimuth scale.

On bottom scale read off length of shadow corresponding to altitude.

Azimuth of shadow equals azimuth of sun plus 180°.

For apparent time p.m. use apparent time a.m. and subtract the given azimuth from 360°.

Azimuth is assumed as measured from north, through east, south and west.

The scales within each quadrant are self-contained and are to be used together and not with the scales in any other quadrant.

No special rules are required for azimuth when hour angle exceeds 6 hours, when latitude and declination are of different name, etc., etc.

Example

To find the azimuth and length of shadow cast by a pole 40 feet high at 8 a.m. apparent time on May 21 (declination 20° N.) at a station 60° N. latitude.

Align declination 20° N. on Declination scale with apparent time 8 a.m. on Apparent Time scale and read off value of a, 54.5°, on a scale and value of r, 126°, on r scale, as shown by broken line A.

Add colatitude of station, 30°, to value of r, 126°, to obtain new value of r, 156°.

Align value of a, 54.5°, on a scale with vlaue of r, 156°, on r scale; and read off value of altitude, 32°, on Altitude scale; and value of azimuth, 286°, on Azimuth scale, as shown by broken line B.

On bottom scale read off shadow length, 1.60, corresponding to altitude of 32°.

The length of shadow is then $40 \times 1.60 = 64$ feet.

The required information is then:

Length of shadow = 64 feet,
Azimuth of shadow = 286°.

The shadow has the same length at 4 p.m. apparent time, but the azimuth becomes $360° - 286° = 74$.

No actual line need be drawn; the results can be obtained by alignment with a straight-edge, preferably celluloid or xylonite.

Where standard time is required instead of apparent time, the change may be effected by applying the equation of time as given in the epherimedes, and correcting for longitude; but such will seldom be necessary as in most cases of sunlight engineering the amount of sunlight received through a window, etc., is the information required rather than the exact standard time of its occurrence.

Similarly the declination for any date may be obtained from the same sources, or from such a source as "An Ephemeris giving the Solar Declination for All Years.[12]

It will be at once apparent that this method of solving the astronomical triangle may be used for many other problems, such as constructing sun-dials, navigation purposes, etc., but in this latter case the azimuths will necessarily have to be changed by 180°. It should also be noted that the solution is a perfectly general one for the spherical triangle when two sides and the contained angle are given and the remaining side and one of the angles are required; also that the particular solution herewith demonstrated applies to any celestial object.

Topographical Surveys,
Interior Department,
February, 1921.

REFERENCES

[1] See also: H. L. Seymour, "Sunlight Engineering in Relation to Housing and Town Planning", Journal of the Royal Astronomical Society of Canada, p. 129, 1920.

[2] Staff Commander W. R. Martin, R.N., "Navigation and Nautical Astronomy", Longmans, Green & Co., London, 1899.

[3] Lord Kelvin, "Tables for Facilitating Sumner's Method at Sea", London, 1876.

[4] Fuss, "Tablizti dlya Nakasdeniya Visott i Azimutoff", Petrograd, 1901.

[5] Lt. Radler de Aquino, "Altitude and Azimuth Tables", J. D. Potter, London, 1910.

[6] Staff Commander Burdwood, R.N., "Sun's True Bearing or Azimuth Tables", J. D. Potter, London, 1912.

[7] Commander W. C. P. Muir, U.S. Naval Institute, Annapolis, Md., "Navigation and Compass Deviations", 1911.

[8] G. W. Littlehales, "The Summer Line and the Compass Error Found by Inspection Instead of by Computation, and Within the Degree of Error that is Inseparable from Astronomical Observations at Sea", printed on back of Pilot Chart of the North Atlantic Ocean, March 1904, Bureau of Equipment, Department of the Navy, Washington, D.C.

[9] Maurice d'Ocagne, "Traité de Nomographie", Paris, Gauthier-Villars, 1899.

[10] Lt. Radler de Aquino, B.N., Naval Attaché to the Brazilian Embassy, "Nomograms for Deducing Altitude and Azimuth and for Star Identification and Finding Course and Distance in Great Circle Sailing", U.S. Naval Institute Proceedings, No. 126, 1908. Maurice d'Ocagne, "Traité de Nomographie", Paris, Gauthier-Villars, 1899. "Exposé Synthétiques des Principles Foudamentaux de la Nomographie" 1903, (Extrait du Journal de l'Ecole Polytechnique), 1903.

[11] E. Deville, LL.D., Surveyor General of Dominion Lands, "Transactions of the Royal Society of Canada", 1906.

[12] W. H. Herbert, B.Sc., "An Ephemeris Giving the Solar Declination for all Years", Annual Report of the Association of Dominion Land Surveyors, p. 174, 1917.

THE ORBIT OF THE SPECTROSCOPIC BINARY BOSS 5070

By W. E. Harper

This star (1900, R.A. = 19h 47.2m, Decl. = +40° 20′; visual magnitude, 5.62; type, B3) was announced a spectroscopic binary by Adams from three plates taken in 1912. A few observations were made by the writer in 1915 and 1917 at Ottawa which suggested the period, and during the past summer sufficient observations were obtained here at Victoria to determine the elements of the orbit.

The Ottawa observations indicated that the calcium K-line did not share in the large oscillations of the other lines and care was taken to have the Victoria plates well exposed in that region. On 19 plates it shows as a fairly sharp line giving a constant velocity -17.4 ± 1.0 km per sec., a velocity which is 11 km more negative than that of the system as a whole, and which, if corrected for the sun's motion through space, would be approximately zero.

Besides the usual hydrogen and helium series whose lines, though 3 or 4 A in width, are fairly well measurable there are faint silicon lines at λ4567 and λ4552, a faint magnesium at λ4481 and occasionally the carbon at λ4267. In general from 5 to 11 lines were measured on each plate.

The period was deduced from connecting up the observations of the four different years 1912, 1915, 1917 and 1920 and gave a value 12.427 days. This element was considered sufficiently well determined and did not enter into the least-squares solution which was effected for the remaining elements and which gave final values as follows, the probable error of a plate being ±3.0 km per sec.

$$P = 12.427 \text{ days}$$
$$e = .199 \pm .021$$
$$\omega = 120.08 \pm 1.29$$
$$\gamma = -6.18 \text{ km.} \pm 1.79 \text{ km}$$
$$K = 94.40 \text{ km.} \pm 2.14 \text{ km}$$
$$T = \text{J.D. } 2{,}419{,}636.226 \pm .076 \text{ day}$$
$$a \sin i = 15{,}808{,}000 \text{ km}$$
$$\frac{m^3_1 \sin^3 i}{(m+m_1)^2} = 1.02 \odot$$

Dominion Astrophysical Observatory,
Victoria, B.C., December, 1920.

NOTE ON NU GEMINORUM

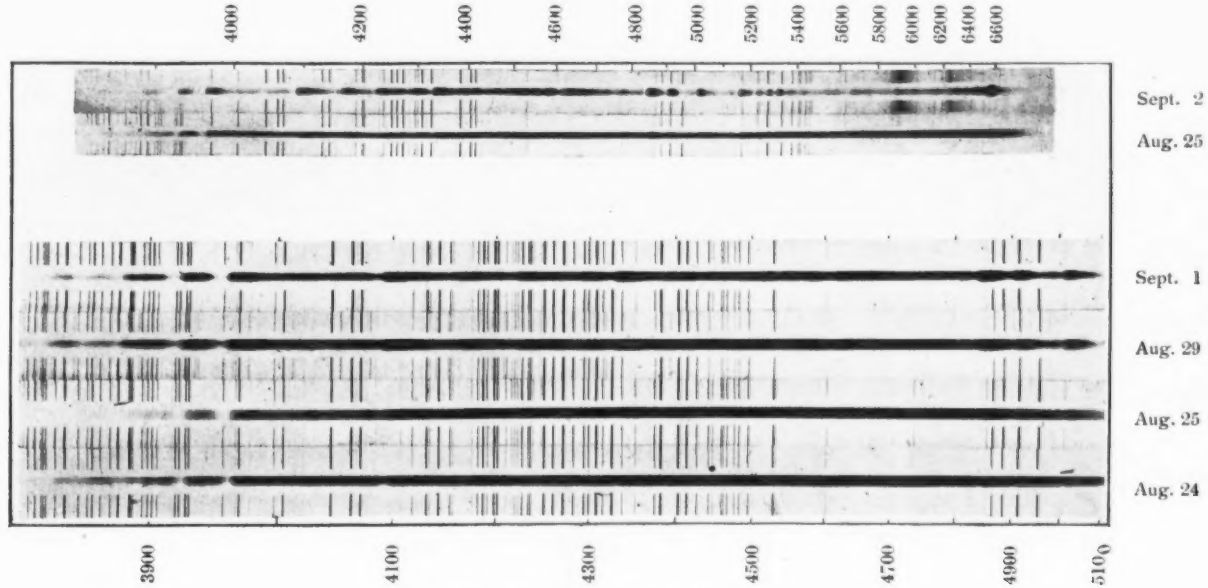
By W. E. Harper

In the April 1919 issue of this Journal the writer gave provisional elements for a long period oscillation in the radial velocity of this star. This seemed to be evident from the mean velocities obtained by grouping plates taken in the same year,—the observations extending over several years. There was also a short period oscillation in the velocities for which a satisfactory period was not obtained. There seemed no doubt, however, of a general trend of the velocities over a curve whose period was 9.6 years.

At intervals since that time spectrograms of the star have been made and the resulting velocities in the majority of cases do not substantiate the long period referred to. It would seem as if the grouping might be purely fortuitous and until further investigation is made it would be unwise to include this star in any statistical discussion of spectroscopic binaries.

Dominion Astrophysical Observatory,

Victoria, B.C., February 24th, 1921.



SPECTRA OF NOVA CYGNI 1920

TAKEN AT THE DOMINION ASTROPHYSICAL OBSERVATORY, VICTORIA, B.C.

SCALE—3.82 times original negatives

THE SPECTRUM OF NOVA CYGNI 1920

By W. E. Harper

On August 20th, 1920, a new star was discovered in the constellation Cygnus by Denning of Bristol, England, while he was engaged in observing and plotting meteor trails. The announcement was cabled to Harvard the following day but did not reach here until the 23rd. For the six weeks or so previous practically every night had been clear, but a spell of cloudy weather set in about that time which greatly interfered with the observation of the star. Then, too, the cloudy spell interfered with our regular observing programme of Boss stars which became crowded in the early evening hours and as a consequence the nova was not observed as frequently as would otherwise have been the case. Nevertheless 19 plates on 12 nights from August 24th to September 28th furnish considerable data which the following discussion aims to summarize.

The spectra were made with the single prism spectroscope attached to the 72-inch reflector. It had been intended to use a three-prism dispersion if the sharp-line stage, noted in former novae, should be recorded. Such was not the case here on any night in which the star was observed, though from reports such a stage was recorded in England. Sixteen of the spectra were made on Seed 30 emulsion with a medium-focus camera giving a range of spectrum roughly from λ3700 to λ5150 with a dispersion of 25.7 A per mm at λ4200, the centre of the plate. The remaining three spectra were made on Ilford Panchromatic plates with a shorter-focus camera taking in a range of spectrum from λ3700 to λ6800 and having a dispersion of 43.4 A per mm at λ4200.

From photographic records there seems to have been no star occupying the exact position of the nova,—at least none brighter than the 17th magnitude. As it attained a maximum on August 23rd equal to a 2nd magnitude star it thus increased in brightness over 15 magnitudes and therefore, while less brilliant at maximum than Nova Aquilae, it outrivalled it in the extent of its variation. Estimates of its magnitude were made here by the writer when clear weather permitted, either with the naked eye or with binoculars or sometimes with the 4-inch finder of the telescope. Dr. R.

K. Young also kept a record of its magnitude from night to night and though made quite independently of one another the estimates generally agreed to 0.1 magnitude. The nova was compared with the surrounding stars, the nmagitudes of these being taken from *Harvard Annals*, Volume 50. My own observations, limited in number as they are, are given below.

Magnitude of Nova Cygni

1920	August	24.7	2.1	Glimpsed through clouds
		25.7	2.3	
		27.7	3.4	
		29.7	3.9	
		30.7	4.1	Little haze
		31.7	4.2	
	September	1.7	4.3	
		3.7	4.6	
		6.7	4.8	
		7.7	4.8	
		24.7	6.5	Brick red
		27.7	7.0	Observed by J. S. P., very red
		28.7	7.2	Very red on slit

While our observations are entirely too few to decide the matter, yet so far as they go they do not reveal any oscillations in brightness so marked in Nova Persei and in Nova Aquilae. The decline was very rapid but continuous.

General Description of the Spectrum

The plates of August 24th showed a strong continuous spectrum with broad absorption lines of hydrogen displaced toward the violet, corresponding to a velocity of 650 km per sec. approach—the equivalent of 9 A at the Hγ region. Broad but faint and more elusive absorption lines which could be identified with enhanced lines of iron and other elements were also present with displacements similar to the hydrogen lines. The H and K lines of calcium were especially strong and similarly shifted. As there seems to be some difference of opinion as to when emission first made its appearance it may not be amiss to record that there seems no reasonable doubt of its presence on our plates of this night at G.M.T. $16\frac{1}{2}$ hours. Its presence at Hγ and farther to the violet is open to question but at Hβ and at the enhanced lines at λ4924, λ5018 and

λ5169 there is a decided strengthening of the continuous spectrum which is unmistakable. Fine sharp H and K lines of calcium undisplaced were also a feature of the spectra as in other recent novae.

The development of the spectrum during the remaining days of August and the first few days of September was marked by the formation of the usual nova emission bands, their increase in intensity relative to the continuous spectrum, and by the increase in the displacement of the absorption bands. From a displacement of 9 A (referred to Hγ) on August 24th these increased to 12 on August 25th, to 16 on August 27th, and seemed to reach a maximum of a little over 17 by the end of the month, the displacement being, as is always the case, to the violet of the normal position of the lines. The equivalent velocities of these displacements are quoted in the Summary of Measures from which it is seen that if these represent the velocities of the expanding shell of gas then they increased in the interval mentioned from 650 km to nearly 1,200 km per sec. As already stated there is some doubt as to the presence of emission bands to the violet of Hγ on August 24th, but they are quite pronounced on plates of the 25th and by the 27th there is a marked difference between the emission and continuous spectrum. On plates of this latter date while all the emission bands show evidences of structure, yet it is most pronounced in the case of the hydrogen bands, they having two maxima at the sides with faint absorption between. A peculiarity of this structure is that in the case of hydrogen the absorption divides the emission band unsymmetrically, there being more of it to the violet than to the red. The plates taken the last week of September showed that the light from the star was mostly concentrated in the emission bands.

The emission lines were strongest at the red end and rapidly became fainter as the violet was approached. On a panchromatic plate taken on September 2nd with a dispersion such that from Hα to K was 32 mm the red Hα line is a very outstanding feature of the spectrum. This band is the probable cause of the strong orange colour to the telescopic image during the latter part of September. The widths of the emission bands are much less than was the case in Nova Aquilae. The three bands to the red of Hβ, namely the enhanced lines of iron at λλ5169, 5018 and 4924, and Hβ itself are each about 28 angstroms in width, Hγ 23, Hδ 19 and K 18 A in width. In the case of Hα there is no doubt of a decided

increase in its width between August 25th and September 2nd, it being very noticeable from even a casual inspection of the plates. If anything, its centre is more to the red on the latter date than on the former but no great weight is attached to this owing to the low dispersion used and the band may be considered as occupying its normal position.

In one particular at least the spectrum differs from the general trend in Nova Aquilae in that the main nebular bands N_1(λ5007) and N_2(λ4959) are not present on any of our plates although a month had elapsed from the star's maximum brightness. In the case of Nova Aquilae No. 3, whose decline in brightness was much less rapid, only about 9 or 10 days elapsed after the star started to wane before the N_1 band appeared and it was followed within the month's time by the other nebular bands at λ4363 and at λ4959.

Positions of the Main Emission Bands

An attempt has been made to determine if the main emission bands occupy their normal positions or if they have suffered any displacement, but owing to the lack of definition of their edges the determinations are not very trustworthy. The mean of all measures indicate a velocity of recession of 31 km per sec., the equivalent of a red-ward displacement of 0.5 A at Hβ. Owing to the very large probable error of the determination, however, I do not look upon this as having any real significance and prefer to consider the bands as occupying approximately their normal positions.

Measures of Absorption Bands

Plate	Camera	Date G.M.T.	Velocity Absorbtion	Lines	Wt.	Sharp H and K	Wt.
4928	Im	1920—Aug. 24.694	− 645	8	2½	−15.2	6
4929	"	" 24.707	− 663	11	2½	−17.4	6
4932	"	" 25.716	− 797	8	1½	−19.6	5
4933	"	" 25.731	− 879	8	2½	−16.6	6
4934	Is	" 25.760	− 847	9	2	−19.3	3
4938	Im	" 27.704	−1103	7	1½	−15.5	6
4939	"	" 27.716	−1099	8	2	−17.1	5
4942	"	" 29.660	−1077	8	1½	−17.2	6
4943	"	" 29.684	−1135	2	½	−16.4	6
4960	"	" 30.710	−1111	2	½	−19.1	5
4961	"	" 30.716	−1190	2	½	−18.0	6
4977	"	" 31.744	−1110	2	½	−17.2	6
4989	"	Sept. 1.715	−1218	2	½	−15.4	5
5010	"	" 2.759	−1196	2	½	−14.7	6
5011	Is	" 2.778	−1164	3	1	−16.0	1
5052	Im	" 6.777	−1185	3	1	−18.0	6
5081	"	" 24.765					
5093	Is	" 27.753					
5111	Im	" 28.727					

The foregoing table summarizes the measures of the absorption bands. At the first, 9 or so of the best of the broad bands were used but by the end of August as their positions seemed to undergo no further change only two or three of the best were measured. These latter results will hence not have quite the accuracy of the first eight but they will closely approximate the correct values as the interagreement was good. The principal bands besides the hydrogen ones and the calcium H and K were enhanced iron lines at λ5169, λ5018 and λ4924. Others were measured and their wave lengths calculated on the assumption that they had suffered displacements similar to the known ones. Thus on the plate of September 6th the following broad absorption bands were present

4623	4476
4586	4472
4555	4450
4497	4424

Sharp H and K Calcium Absorption

Attention has been called to the fine undisplaced calcium lines and the foregoing table also contains the measures of the 16 plates on which the lines are seen. The velocity appears to be quite constant, with a mean value -17.0 ± 0.25 km per sec., practically identical with the component of the solar motion in that direction. Thus if these lines, by their position, indicate the real motion of the star it is practically at rest with respect to the stellar system. Such of course was found to be the case in Nova Persei 1901, Nova Geminorum 1912 and Nova Aquilae 1918.

The illustrations used are direct enlargements of the spectrum plates the magnification being 3.82 diameters. Being prints of enlargements of the original negatives they are, of necessity, negatives themselves.

While the writer is responsible for the measurement and discussion of the plates, all of the observers shared in the work of securing them. Detailed measures of various other features of the spectra will be given in a forthcoming Publication of this observatory.

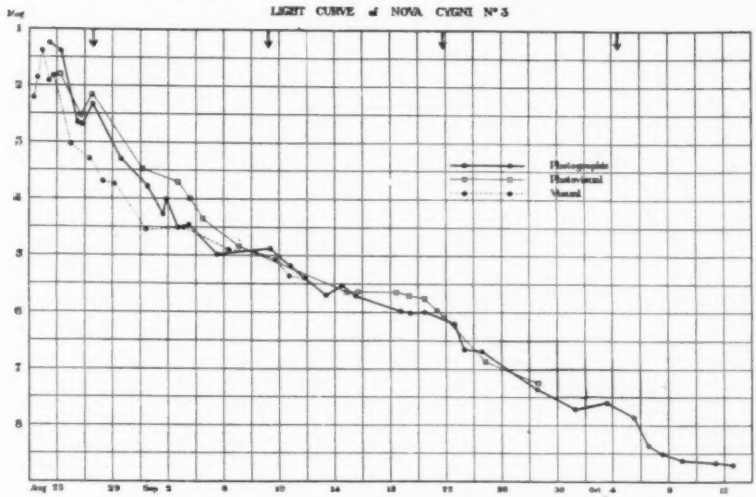
Dominion Astrophysical Observatory,
January 14th, 1920.

THE PHOTOGRAPHIC LIGHT CURVE OF NOVA CYGNI NO. 3

By F. Henroteau

The following light curve was obtained from photographs taken at the Dominion Observatory by the author as well as by Mr. J. P. Henderson, Mr. R. M. Stewart and Mr. E. C. Arbogast. The photographs were taken with a small wide-angle camera covering a field of the sky of about 20° in diameter. Usually photographic light curves are obtained only for faint stars because of the scarcity of bright comparison stars in small fields, but with the above plates it was found rather easy to obtain a fair value of the magnitude of the nova even when very bright; the method of degrees, usually known as Argelander's method (when applied to visual comparisons) was used to obtain good estimates of the magnitudes; the method which consists in finding stars in the field, which are of very nearly of the same magnitude as the variable, is usually exempt from large systematic errors.

Two series of photographs were secured, the first one on Seed 30 plates (ordinary photographic plates) and the second on Cramer Isochromatic plates (medium) which are more sensitive to the



yellow and perhaps to the red. The use of a yellow screen when using these plates would give us magnitudes very nearly the same as the visual; such a screen was not used however, but the magnitudes obtained for the nova from these plates were considered as visual so that the light curve obtained is very likely slightly different from what it really ought to be. This second curve, which we call photo-visual, follows the photographic curve rather closely; however, not too much importance ought to be attached to it.

The following tables give the magnitudes as determined by the author from the different plates.

Magnitudes obtained from photographs taken on Seed 30 plates

No.	Observer	Date 1920	Exposure G.M.T. Beg.	Exposure G.M.T. End	Duration	Photo. Mag.	Remarks
			h m	h m	h m		
34	Henroteau	Aug. 24	13 5	13 40	0 35	1.20	..
35	Henroteau	Aug. 25	13 9	?		1.33	..
36	Henderson	Aug. 25	18 24	18 39	0 15	1.98	..
38	Henroteau	Aug. 26	13 10	13 47	0 37	2.63	..
39	Henderson	Aug. 26	19 45	20 10	0 25	2.63	..
41	Henderson	Aug. 27	19 3	19 33	0 30	2.30	..
43	Henroteau	Aug. 29	15 54	16 8	0 14	3.27	..
44	Stewart	Aug. 30	13 13	13 50	0 37	3.75	..
46	Arbogast	Sept. 1	13 42	14 11	0 29	4.22	..
48	Stewart	Sept. 1	18 59	19 21	0 22	3.98	..
49	Stewart	Sept. 2	13 4	13 44	0 40	4.46	..
51	Arbogast	Sept. 3	12 56	13 47	0 51	4.42	..
55	Stewart	Sept. 5	14 1	15 30	1 29	4.92	..
57	Henroteau	Sept. 9	13 4	13 45	0 41	4.84	..
58	"	Sept. 10	14 40	15 26	0 46	5.18	..
59	"	Sept. 13	12 35	13 15	0 40	5.69	..
61	"	Sept. 14	12 35	13 11	0 36	5.50	..
65	"	Sept. 15	13 56	15 55	1 59	5.69	..
68	Henderson	Sept. 18	19 2	19 40	0 38	5.95	..
70	Henroteau	Sept. 19	13 40	15 0	1 20	5.98	..
71	"	Sept. 20	13 28	15 40	2 12	5.98	..
74	"	Sept. 21	12 21	12 54	0 33	5.91	..
76	"	Sept. 22	12 28	12 50	0 22	6.20	Clouds
77	"	Sept. 23	12 31	12 53	0 22	6.63	..
79	"	Sept. 24	12 6	12 40	0 34	6.63	..
82	"	Sept. 28	12 42	13 27	0 45	7.33	..
86	"	Oct. 1	13 17	13 59	0 42	7.70	..
87	"	Oct. 3	13 3	13 27	0 24	7.60	..
89	"	Oct. 5	12 29	13 55	1 26	7.85	..
93	"	Oct. 6	13 15	14 15	1 0	8.33	..
95	"	Oct. 7	13 19	13 56	0 37	8.50	..
96	"	Oct. 8	12 40	13 39	0 59	8.60	..
102	"	Oct. 11	16 1	16 51	0 50	8.65	Clouds
103	"	Oct. 12	12 46	13 36	0 50	8.70	..

Magnitudes obtained from photographs taken on Cramer isochromatic plates

No.	Observer	Date	Exposure G.M.T.		Duration	Photo. Mag.	Remarks
			Beg.	End			
			h m	h m	h m		
37	Henderson	Aug. 25	18 48	19 23	0 35	1.74	..
40	"	Aug. 26	20 25	21 5	0 40	2.43	..
42	"	Aug. 27	20 13	20 36	0 23	2.15	..
45	Stewart	Aug. 30	14 23	15 32	1 9	3.45	..
50	"	Sept. 2	14 8	15 0	0 52	3.61	..
52	Arbogast	Sept. 3	14 13	15 7	0 54	3.94	..
54	Stewart	Sept. 4	17 20	18 11	0 51	4.32	..
56	Henroteau	Sept. 7	13 15	13 47	0 32	4.80	..
62	"	Sept. 14	13 48	14 26	0 28	5.60	..
64	"	Sept. 15	12 20	13 4	0 44	5.60	..
67	Henderson	Sept. 18	16 50	18 50	2 0	5.60	..
69	Henroteau	Sept. 19	12 24	12 58	0 34	5.66	..
72	"	Sept. 20	16 6	16 23	0 17	5.72	..
75	"	Sept. 21	13 26	13 58	0 32	6.10	..
78	"	Sept. 23	13 8	13 34	0 26	6.91	..
80	"	Sept. 24	13 3	13 40	0 37	6.91	..
83	"	Sept. 28	13 59	14 13	0 14	7.30	..

For the brightest comparison stars the magnitudes were taken from the Revised Harvard Photometry (*Harvard Annals*, Vol. 50) while the magnitudes of the faintest stars were determined from the above plates, by comparing plates of very different exposures, hence of different intensities.

The above magnitudes give the light curves of the figure. The dotted line is the visual light curve as determined from the magnitudes given by C. Luplau Janssen and Georg E. H. Haarh (Urania Observatory, *Communications* No. 1). The nova was thus at first fainter visually than photographically, while toward the middle of September the magnitudes are the same, and probably further data as to the visual curve will show that in October the star was brighter visually than photographically. The colour indices indicated by the differences of ordinates of the two curves are in good agreement with the change of colour (variations of effective wave-lengths as given in the same Urania Observatory Communication); the nova was at first rather blue and then more yellow and when observed here in October it was red, hence we have to expect the photographic curve to have a greater inclination than the visual.

The accompanying photographic curve indicates that a maximum may have occurred about every 12.6 days as indicated by the arrows. A periodicity of the same kind has been found for other novae, namely Nova Aquilae No. 3 whose visual light curve has been determined by P. Stroobant at the Royal Observatory of Belgium. The maxima in the present case are however not as pronounced as those of Nova Aquilae.

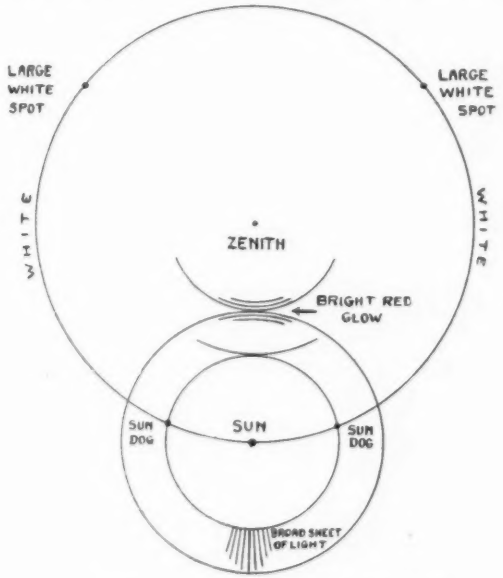
Dominion Observatory, Ottawa,
November 27th, 1920.

A FINE SOLAR HALO

By T. H. LENNOX

At 1 o'clock p.m., Sunday, Feb. 20th, at Youngstown, Alberta, I saw a very remarkable halo of which I made a diagram and took notes while observing it. The accompanying diagram, although not drawn to scale, represents roughly the relative size of the circles. The morning had been cold (−14° F.), but at 1 p.m. the temperature was 0° F. with a moderate wind S-S-W. The atmosphere was hazy and full of floating ice crystals which could be seen flashing in thousands overhead.

There were two concentric circles about the sun at, I suppose, the usual angles, 22 and 46 degrees, respectively. Another circle,



HALO SEEN AT YOUNGSTOWN, ALBERTA
ON FEBRUARY 20, 1921

passing through the sun, cut these two circles and made a complete circuit of the heavens at the altitude of the sun. There were two very bright sun-dogs at the intersections of this circle with the inner or primary circle, and two faint white patches on it far to the north and perhaps 90 degrees apart.

Another circle, incomplete, apparently with the zenith as its center, was tangent to the outer or secondary circle and at the contact was a very bright fiery-red glow, passing upward into yellow and bluish colours. Directly below this point was a very small arc of a circle tangent to the primary, also having the zenith for center.

At the lower side of the primary circle a broad sheet of light, like a vertical section of a truncated cone extended from the primary almost to the secondary. Three or four bands of colour, exactly like the supernumerary bows frequently seen inside the ordinary rainbow, accompanied the primary and secondary circles. They were to the outside and partly within the substance of the white ring.

On the evening of the 23rd inst., there was a bright ring about the moon with a brighter spot at each side and a fainter one below.

Youngstown, Alberta.

THE SPECTROSCOPIC ORBIT OF OMICRON DRACONIS

By R. K. Young

o Draconis (1900 R.A., 18 h 49.7 m; Dec., +59° 16′) was announced as a spectroscopic binary from the Lick Observatory in 1910. Its spectral class is K and the lines are of very good quality. For a long time it has seemed to the writer that there is need for more orbits of late type stars for statistical purposes. Thus of the two hundred orbits determined there are less than 30 of later type than F. The reason for this small number is quite plain. Almost all the observatories determining binary orbits are using 1-prism instruments and the late type stars do not usually have a sufficiently large range to enable accurate elements to be determined. The very satisfactory behavior of the 1-prism spectrograph attached to the 72-inch telescope and the small probable errors obtained when the plates are measured on the Hartmann Comparator, however, make it quite possible to obtain good approximate elements for many of these stars. Observations have been started of the stars listed below in Table I. Many of them show evidence of periodicity already.

Table 1

Star	R.A. 1920	Dec. 1920	Type	Star	R.A. 1920	Dec. 1920	Type
	h m	° ′			h m	° ′	
33 Piscium	00 01.2	− 6 19	K	4 Ursae Min.	14 07.8	+77 55	K
ξ Piscium	01 49.2	+ 2 49	K	BD66 .878	14 56.3	+66 15	Ma
δ Trianguli	02 11.9	+33 52	G	Boss 4129	16 09.0	+36 38	K5
τ Persei	02 48.6	+52 26	Gp	Boss 4660	18 21.8	+ 8 00	K
ρ 17 Orionis	05 09.1	+ 2 47	K	β Scuti	18 42.9	− 4 50	G
16 Aurigae	05 12.9	+33 18	K	δ Sagittae	19 43.8	+18 20	Map
π 7 Gerinorum	06 10.0	+22 32	Ma	*l* Aquilae	20 34.2	− 1 23	K
Boss 2463	09 08.0	+61 45	F8	μ Cephei	21 40.8	+58 24	Ma
12 Coma Ber.	12 18.5	+26 17	Gp	24 Cephei	22 08.3	+71 57	K

In all only 12 observations of *o* Draconis were secured at Victoria and the five observations taken at the Lick Observatory since 1902 and the two observations taken at Bonn in 1911 supplemented these in the most desirable way enabling both the shape and the period of the curve to be determined. The observations are listed in Table II.

TABLE II

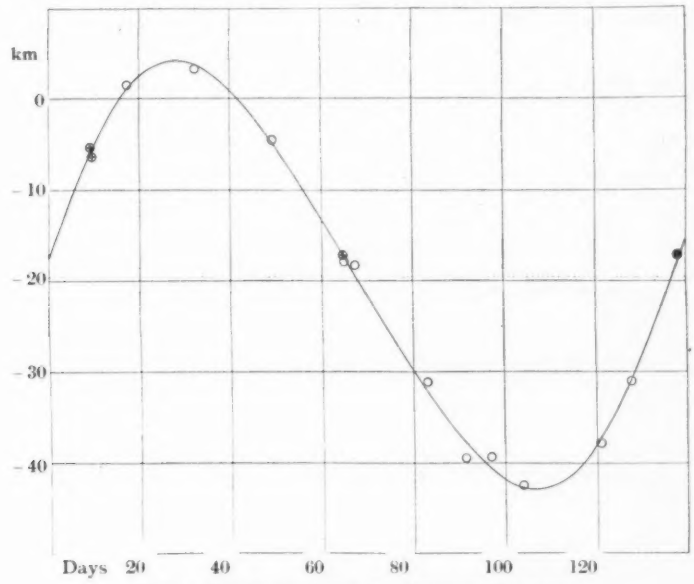
Plate Number	Date	Julian Date G.M.T.	Phase from Final T	Velocity	O−C Final	O−C Prelim.
Lick	1902 July 14	2,415,945.757	9.68	− 6.40	−0.8	+ .4
"	1907 June 17	7,744.842	9.30	− 5.35	+0.6	+1.6
"	1909 June 30	8,488.797	61.16	−14.81	−0.6	−2.0
"	July 7	8,495.881	68.24	−20.16	+0.1	−1.3
Bonn	1911 Aug. 8	9,257.36	137.62	−16.0	+2.6	+2.4
"	" 9	9,258.36	138.62	−18.4	−1.0	−1.2
Victoria						
4513	1920 June 30	2,422,506.841	65.02	−17.9	−0.4	−1.3
4645	July 18	2,524.828	83.01	−31.2	+1.0	+0.8
4695	" 25	2,531.799	89.98	−40.6	−3.6	−3.4
4735	" 28	2,534.800	92.98	−38.4	+0.2	+0.4
4753	Aug. 1	2,538.796	96.98	−39.4	+1.1	+1.5
4818	" 8	2,545.790	103.97	−42.5	+0.3	+0.5
4935	" 25	2,562.800	120.98	−37.9	−0.3	−0.9
4991	Sept. 1	2,569.747	127.93	−31.0	−0.0	−1.1
5128	" 29	2,597.692	17.47	+ 1.5	+0.5	+1.5
5210	Oct. 14	2,612.589	32.37	+ 3.3	−0.4	+0.5
5363	" 31	2,629.584	49.36	− 4.5	+0.4	+0.0
5494	Nov. 18	2,647.593	67.37	−18.3	+1.2	+0.4

An approximate period of 138.4 days was deduced from the observations and the early measures when plotted with this period are well represented. It was advisable to include the period in the least-squares solution made for the final elements. The two observations taken in 1909 at the Lick Observatory were grouped into one normal place. The two Bonn observations were similarly treated and also the observations of July 25 and 28 made at Victoria. This gives 15 normal places. All the normal places were given the same weight save the one formed from the two 3-prism plates of the Lick Observatory which was given weight 2. In effect this gives the early 3-prism plates the same weight as the recent 1-prism. This was done because the majority of the observations were made at Victoria and it was felt that the shape of the curve should rest primarily on the recent observations. To have given the early observations the weight which their accuracy justifies would, in view of possible systematic differences between results at the two observatories, had a disturbing effect on the elements.

The final elements with their probable errors are

Period	P = 138.420 days	± .016
Eccentricity	e = 0.114 "	± .014
Longitude of periastron	ω = 274°.31 "	±6°.36
Periastron passage	T = J.D. 2,419,258.16	±2.43 days
Velocity of system	γ = −19.525 km.	±0.21 km.
Semi-amplitude	K = 23.46 km.	±0.30 km.

The probable error for a normal place of weight unity was 0.68 km. The probable error for a single 1-prism observation taken at Victoria is 0.81 km and if we omit the third observation, which has an unusual high residual, we obtain the low value 0.67.



RADIAL VELOCITY CURVE OF OMICRON DRACONIS

The normal places are plotted on the graph showing the radial velocity curve. The Lick observations are the circle and cross. The Bonn observations the filled circle and the others are the 1-prism observations with the 72-inch telescope.

Dominion Astrophysical Observatory,
Victoria, B.C.,
December 15, 1920.

MEETINGS OF THE SOCIETY

At Toronto

March 1.—The Society met in the Physics Building of the University at 8 p.m. the President, Mr. J. R. Collins, in the chair.

The following were elected Members of the Society:

Nostell K. Anderson, Gaylordsville, Conn., U.S.A.
Thomas Waddell, Lake Lodge Farm, Brechin, Ont.
Guy M. Shaw, Huxley, Alberta.
Robert Holmes, 24 Isabella St., Toronto.
H. G. Hayman, 6 Millbrook Crescent, Toronto.
Arthur Amos, Dept. Lands and Forests, Quebec City, P.Q.
W. W. Shaver, B.A., University of Toronto.
A. H. Bell, 406 Huron St., Toronto.
Miss Maude McCann, 131½ Wolfrey Avenue, Toronto.
Miss Claire Miller, B. A., 100 Queen's Park, Toronto.
Edward York, Devonshire, Bermuda.
James McLaughlin, Smiths, Bermuda.

Sir Frederic Stupart, Director of the Meteorological Service gave the paper for the evening, his subject being, "Facts, Fallacies and Fancies about the Climate."

Sir Frederic discussed the various climates existing in different parts of the globe. In general, at the equator the temperature varies little, and seldom falls below 80 degrees. The greatest range on record is found in North Eastern Siberia, where the mean temperature of July is 59° and that of January—61°, a difference of 120 degrees. Similarly there is great variation in the amount of rainfall in different regions. A section of India holds the record of 41 inches in a day, and 905 inches in one year.

The lecturer described the characteristics of the zones, as seen by an aviator flying at a convenient height from pole to pole. Many changes would be observed upon a second trip, six months later.

The circulation of the atmosphere is due to two main causes, viz., the higher temperatures existing in the tropics causing the air over this zone to ascend and spread towards the poles; and secondly, to the rotation of the earth. On account of the fact that the meridians converge, the air currents become piled up in latitudes 30° to 40°, producing storms, tornadoes, and cyclones. Changes in climate occur, if at all, very, very slowly. Instrumental records at Winnipeg extending over 50 years do not indicate a change in that time. Historical records go to show that the climate of Palestine and Southern Europe 2,000 years ago was similar to that of to-day.

Two of the Meteorological fallacies still in evidence to day are the beliefs in the moon's influence on the weather and in the artificial creation of rain. At

the present time the Farmer's Association of Southern Alberta are negotiating with a certain Mr. Hatfield, an American, to have him produce four inches of rain over their territory!

Meteorological maps were shown to illustrate the difference in our seasons from year to year. This winter has been very similar to that of 1918-19. The abnormal flow of intense cyclonic areas over Alaska, has prevented the formation of those cold currents of air which sweep across the western provinces and Ontario, and thus our winter has been mild. This situation is accounted for in the following way. An increased solar radiation causes an increased barometric gradient in the tropics, so that the trade winds possess a greater velocity than usual. The Japan current therefore carries warmer water into the Upper Pacific, producing the cyclonic areas over Alaska.

March 15.—The Society met in the Physics Building of the University at 8 p.m., the President, Mr. J. R. Collins, in the chair.

Prof. Alfred Baker, of the University of Toronto, gave the lecture of the evening, his subject being "Sun Dials."

The earliest mention of sun dials is the reference found in the book of Isaiah, which was written about 600 B.C. The first dial whose construction is known was that of Berosus, a Chaldean astronomer, 300 B.C. His dial was a hemispherical bowl, placed with its rim perfectly horizontal; wires intersecting at the centre made a knot, the shadow of which described an arc upon the inside of the bowl. This arc was divided into twelve equal parts called the temporary hours, and as each was the twelfth part of each period of daylight, the hours varied considerably from season to season.

This form of sun dial existed far into the Christian era, being replaced by more accurately constructed ones in the 14th and 15th centuries, which in turn were superseded by clocks and watches in the 18th century.

Prof. Baker explained the accurate construction of the equatorial, horizontal and vertical dials, developing the trigonometrical formulae involved. Three methods for properly placing the dial in the meridian were described, as it is most essential that the dial be correctly orientated.

The older dials were elaborately decorated, and invariably had mottoes engraved upon them, suggesting the flight of time, and old age's rapid approach. The lecturer gave some two dozen of the most interesting examples of the mottoes found on the dials of both continents. It is interesting to note that the earliest Anglo-Saxon inscription in England is found on the sun dial at Newcastle, in Northumberland, dating from 670 A.D.

When the University of Toronto fire occurred in 1890 the Tower bell was melted, and from the metal Prof. Baker made a dial, bearing the Latin hexameter: "Ecce sonans, olim, mutum nunc, auguror horas." (Formerly noisily, now silently, I mark the hours). This interesting timepiece was placed in the Dean's garden, where it remained for several years. It was finally removed however, shortly before one Hallowe'en.

J. A. PEARCE,
Recorder.

AT MONTREAL

February 22.—The meeting was held in the Engineering Building, McGill University, the President, H. E. S. Asbury, occuping the chair. There was an attendance of 26.

The following were elected members of the Society:
Ernest P. Ridgewell, Montreal.
Robert Graham, Montreal.
A. Browning, Montreal.
Lawrence G. Cluxton, Montreal.
E. E. O'Connor, Strathmore, Que.

The President read some notes sent in by W. T. B. Crombie, covering observations recently made by him on the planets Mercury and Venus. Extracts were also read from several *Harvard Bulletins*.

The speaker of the evening, F. R. Robert, one of our members, was then called upon to address us on "Primitive Solar Observations." Mr. Robert, in the course of a most interesting and instructive address, pointed out that many of the old Celtic monuments found in Great Britain, Wales, the Channel Islands, Brittany and in Western Europe generally were erected to serve for astronomical observations.

Norman Lockyer, the English astronomer, in his book on Stonehenge, shows how the age of these monuments may be calculated by their orientation and the position of their pointers on the skyline.

Four thousand years ago, the longest and the shortest days, seed time and harvest, the yearly return of important festivals, were determined by observations of the sun's position on the skyline. A measurement of the sun's apparent diameter was attempted more than 2,000 years ago by Eratosthenes of Alexandria. By finding the length of shadows cast by upright rods on the day of the summer solstice and comparing his results with similar measurements taken elsewhere, Eratosthenes was able to determine the length of a terrestrial meridain . By the same method he found, within half a degree, the obliquity of the ecliptic.

Aristarchus of Samos, who lived 200 B.C., showed how the relative distance of the sun, moon and earth could be worked out from observations taken when the moon is 7 or 21 days old. It was not till 150 years later that a fairly good solution to this problem was given by Posidonius.

Mr. Robert maintained that with all this information the ancients could have worked out graphically the actual size and distance of the sun and thus obtained a notion of the relative insignificance of the earth in the solar system. For 1700 years this information was available, but was not used until Copernicus startled the world by showing that the earth was of little account in the universe.

A hearty vote of thanks, moved by Mr. Justice Howard, seconded by A. Browning, was passed to the speaker.

The meeting concluded wi h the singing of the National Anthem.

H. E. MARKHAM,
Recorder.

NOTES FROM THE METEOROLOGICAL SERVICE

FEBRUARY 1921

TEMPERATURE

The temperature was just average in Vancouver Island and on the north shores of British Columbia, average to 2° below in Eastern Quebec, New Brunswick, and the greater portion of Nova Scotia, decreasing to 3° and 4° below in Prince Edward Island and Cape Breton. Elsewhere it was everywhere above the average. In the interior of British Columbia it was from 2° to 5° above, in the Western Provinces from 7° to 11° above, in Ontario from 4° to 12° above, and in Western Quebec from 2° to 3° above.

TEMPERATURES FOR MONTH OF FEBRUARY, 1921

STATIONS	FEBRUARY Highest	Lowest
Yukon		
Dawson	38	−48
British Columbia		
Atlin	40	−32
Agassiz	64	20
Barkerville	45	− 6
Kamloops	55	3
New Westminster	56	23
Prince Rupert	54	15
Vancouver	56	22
Victoria	55	28
West Provinces		
Battleford	50	−35
Calgary	60	−10
Edmonton	53	−23
Medicine Hat	57	−10
Minnedosa	38	−34
Moosejaw	55	−18
Oakbank	42	−27
Prince Albert	46	−36
Qu'Appelle	45	−35
Regina	47	−33
Saskatoon	47	−30
Souris	39	−18
Swift Current	56	−18
Winnipeg	40	−26
Ontario		
Agincourt	52	4
Aurora	49	0
Bancroft	42	−10
Barrie	51	− 2
Beatrice	49	−10
Bloomfield	48	5
Chapleau	42	−27
Chatham	59	13
Clinton	55	4
Collingwood	55	4
Cottam	40	4
Georgetown	53	6
Gravenhurst	49	− 9
Grimsby	52	8
Guelph	52	5
Haliburton	44	−15

STATIONS	FEBRUARY Highest	Lowest
Ontario—cont.		
Huntsville	49	−12
Kenora	36	−27
Kingston	50	6
Kitchener	51	7
London	56	6
Lucknow	52	− 2
North Gower	45	− 5
Oshawa	38	9
Ottawa	45	− 8
Paris	55	5
Parry Sound	48	− 8
Peterborough	53	− 1
Port Arthur	39	−13
Port Burwell	45	7
Port Dover	50	7
Port Stanley	46	10
Queensborough	49	− 8
Ronville	47	−14
Southampton	55	5
Stonecliffe	48	−24
Stoney Creek	55	10
Toronto	53	7
Uxbridge	50	0
Wallaceburg	35	10
Welland	56	9
White River	38	−38
Quebec		
Brome	47	−18
Father Point	36	−18
Montreal	40	0
Quebec	38	−11
Sherbrooke	49	− 9
Maritime Provinces		
Charlottetown	36	−14
Chatham	42	−20
Fredericton	..	..
Halifax	44	− 6
Moncton	40	−21
St. John	46	− 4
Sussex	44	−25
Sydney	36	−14
Yarmouth	44	2

Precipitation

The precipitation in British Columbia was a little above the average in some localities and below in others, except on the northern coast line where it was very heavy. In the Western Provinces, in the northern portion it was exceeded, whereas in the southern parts there was as a rule, rather less than the usual amount. In Ontario except in one or two isolated places, it was much below the average. In Quebec it was even more below than in Ontario. In the Maritime Provinces it was above the average in Prince Edward Island and Cape Breton, and generally a little below elsewhere.

SEISMOLOGICAL NOTES FOR FEBRUARY

Toronto recorded fourteen disturbances and Victoria thirteen. The most important occurred on the 4th, 11th, 19th, 21st and 27th. The others were small. The max. trace amplitude on the 4th at Toronto was 7 mm., occurring at 8h 42m, and at Victoria it was 2.5 mm., occurring at 8h 48m. The epicentre of this quake was in the Isthmus of Techuantepec, Mexico, and caused the loss of many lives. Five disturbances were recorded at Victoria on the 21st, with amplitudes ranging from 0.2 to 2.0 mm. Three of these are strikingly similar in character, the seat of the disturbance being about 600 km. from Victoria, possibly in Alaska. The earthquake on the 27th may have been in China in the region of the destructive quake of December 16th.

J. Y.

MAGNETIC DISTURBANCES

The month of January 1921 was almost entirely free of disturbance of the magnetic elements at both Agincourt and Meanook. This condition of the earth's magnetic field was synchronous with sparsity of auroral phenomena and sunspots. The aurora was most pronounced from the 10th to the 12th, but during the rest of the month was only occasionally reported. Small groups of sunspots were central on the sun's disc on the 5th, 9th, 14th, 17th and 25th.

W.E.W.J.

ASTRONOMICAL NOTES

PARALLAXES DEDUCED FROM ORBITAL MOTIONS

The hypothetical parallaxes of 556 visual double stars, with a determination of the velocity and direction of the solar motion. By J. Jackson and H. H. Furner. (*M. N.*, Nov. 1920, p. 2).

For the orbit of a visual double we have from fundamental dynamics

$(m_1+m_2)p^3=a^3/P^2$

where m_1+m_2 = combined mass in units of the sun's mass.

p = parallax in seconds of arc

a = semi-axis major in seconds of arc

P = period in years.

Knowing either the mass or the parallax we can therefore deduce the other, in the case of a known orbit. As it is known that the mass of double stars is on the average very nearly twice that of the sun, parallaxes can be deduced which in most cases wil be very near the truth.

In the case of doubles where even only two or three relative positions have been determined, the authors deduce approximate formulae for the determination of parallax, one of which is practically identical with formulae used by Russell and Hertzsprung previously.

Using these methods parallaxes are deduced for 556 stars; in the comparatively few cases where accurate parallaxes have been otherwise determined the agreement appears satisfactory.

Combining the data so obtained with the known proper motions of 327 of these stars, the authors obtain for the apex of the solar motion:

R. A. 273°, Dec. 33°.8, velocity 19.13 km. per second.

Based on the same data a discussion is given, for all 556 stars, of their distribution in absolute magnitude for different spectral types, and of their distribution in space. R.M.S.

ASTRONOMICAL UNITS

The American Section of the International Astronomical Union present their report, and in it they make the following suggestion.

1. Distance—So far as practicable let the unit distance be
   - (*a*) the kilometer, (in reference to dimensions of the sun, planets, etc.) It can even be used in expressing stellar distances without employing larger numbers than the physicists are accustomed to, in speaking of the number of molecules in a cc. of gas.
   - (*b*) the astronomical unit, *i.e.*, mean solar distance, (in reference to the solar system chiefly.)
   - (*c*) the light year, (especially in popular articles).
   - (*d*) the parsec, (wherever appropriate; or preferably a unit 10 times as great, to be given a separate name.)

2. Absolute Magnitude—The meaning given to the expression 'absolute magnitude' should be the magnitude at the distance of 10 parsecs, at which the star's parallax would be 0".10.
3. Unit of Heat—Use the Joule for the unit of heat instead of the calorie, as the latter is not defined unless explained.
4. Unit of Wavelength—Use the International Angstrom.
5. Unit of Pressure—One bar *i.e.* 100 dynes per sq. cm. This is in keeping with very general use in meteorology.

J.A.P.

VARIABILITY OF THE SUN CONFIRMED

(Report on the Smithsonian Astrophysical Observatory for the year ending June 30, 1920, by C. G. Abbot, Director).

By means of photo-electric observations made from January to May 1920 on the planet Saturn, Guthnick, of the Berlin-Babelsberg Observatory, obtained variations in the brightness of the planet which could not be accounted for after allowing for all known sources of variability. These outstanding variations were found to be in almost exact correlation with fluctuations in the solar radiation as observed at Calama, Chile. One per cent. increase in solar radiation was accompanied by one per cent. increase in Saturn's brightness. There was one peculiarity, however, the variations in the sun and in the planet were not simultaneous.

Now the sun's corona has a ragged ray-like structure and it is not unnatural to suppose that the radiation of the sun in different directions is different. If this were the case the variations in radiation would reach Saturn in the order in which we would observe them, but after a certain interval depending on the position of the bodies. This accounted satisfactorily for the peculiarity mentioned. This hypothesis also relieves the difficulty in understanding how such a great body as the sun can undergo variations in brightness in the short periods of 5 to 10 days.

A METEOR FALL IN THE ATLANTIC

Henry S. Washington in "*Science*," Jan. 28, 1921, (p. 90).

Record is made of an extraordinary fall of meteorites on October 30, 1906, observed from the Steamship "St. Andrew," about 600 miles north-east of Cape Race. Just after 4.30 p.m. three bodies fell into the water dead ahead of the ship and five miles away, and one huge saucer-shaped meteorite fell less than a mile off on the port side. Though in full daylight, it left a broad red streak behind it and the hissing of the water could be heard as it touched, and the steam and spray rose at least forty feet.

The Steamer "Brazilia" reported having seen a large meteor at 7 p.m. on the same day in Lat. 47° N. and Long. 48° W. The two events may have been connected but the difference in time makes this seem improbable.

The reviewer recalls a similar occurrence seen from the Steamer "African Prince" on October 17, 1906, and noted in this Journal, vol. I, p. 13 (1907).

C.A.C.

BOOK REVIEWS

PUBLICATIONS RECEIVED

From the Leander McCormick Observatory comes a noble volume of 696 pages containing the parallaxes of 260 stars derived from photographs. Director Mitchell and his small staff is certainly doing wonderful work.

From the Yerkes Observatory is received vol. 4, part 3, of its *Publications*, containing the parallaxes of 52 stars by Van Biesbroeck and Mrs. Steele. The greatest parallax is 0″.509, being that of Barnard's proper motion star.

Tables du Mouvement Képlérien by F. Boquet (part 1) is a publication of great value to the practical astronomer. It contains 206 pages and is issued by Hermann in Paris with the aid of a subvention from the Academy of Sciences.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

DEATH OF PROFESSOR S. W. BURNHAM

Sherburne Wesley Burnham, professor of practical astronomy at the University of Chicago from 1902 to his retirement in 1914 and astronomer at the Yerkes' Observatory, died on March 11, in his eighty-third year.

The achievements of Burnham are well-known. While a court reporter in Chicago, he mounted a six-inch telescope in his back-yard and soon became famous for his discovery of double stars. When the Lick Observatory was organized for work he was given a position on its staff, and later he returned to Chicago. His greatest contribution to science was of course his long list of new doubles, but the pattern he set for observers, his kindly advice and assistance to amateurs and professionals and the invaluable *General Catalogue* prepared by him will long be remember ed in the history of astronomy.

For many years he was an Honorary Fellow of the Royal Astronomical Society of Canada.

The Royal Astronomical Society of Canada

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